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Analysis of the Low Perception of Risk: Causes, Consequences, and Barriers

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Abstract

The principles of risk, danger, and sociability depend on cognitive limitations and the social work environment. Subjects are linked in binaries or multiples where they can establish causal relationships or influences that lead to informal rules of behavior in the workplace. A group that understands what positively influences the organizational goal of avoiding accidents and losing energy will know the importance of keeping the fundamentals of work alive. Understanding the principles is the basis for research into safe, alert, and resilient behavior. From the characterization of the principles adopted in the form of relationships, from the established standards of good practices, they present hypotheses about safe behavior. The hypotheses may indicate gaps in the difference between what is expected for a risk activity (good practices) and what is detected from the observation scenarios of this industrial routine. In the cognitive analysis based on the models that indicate perception, attention, and memory are initial stages for the construction of the mental scheme of execution of preformatted procedures or elaboration of procedures in unusual situations. A comparative analysis for a group indicates which aspects considered as priorities for decision and common sense allow a more complex preparation that requires a new concept. In the job search are the physical, cognitive (information flow and type of communication) and organizational situations that can cause human error and equipment failure. Working criteria can decrease or increase human error. This work aims to test the principles and indicate the hypotheses through the analysis of scenarios and confirm the relationships of the lack of perception of risk, with the analysis of the work station indicating which factors of performance that influence the human error. When designing interventions, it is important to suggest the influence of competence level and quality of communication tools in a stressful environment with specific leadership. Interventions depend on the type of human error, therefore, on the application of intellectual capital, operational groups for situations under stress, change of habits and educational campaigns.

Keywords: Work Station - Risk Perception - Human Error - Behavior - Industry

1 Introduction

Sensitizing teams to change behavior and preparing preliminary diagnosis on the motives of lack of risk perception. To achieve these goals, appropriate methodologies were developed that seek to break down social paradigms about accidents through training work teams. Reflections in crisis situations assist in the elaboration of hypotheses for future interventions in operational mass and environments, reinforcing personal, organizational and regional safety policies. The choice of interventions depends on their validation in later work. It is important to distinguish the elements that induce unsafe behavior and the human-organizational-technical (HOT) factors that cause human error, losses, and accidents. The managerial, human-social and technological aspects can create an environment for unsafe behavior, in which they allow the flow of danger energy across barriers. The human and organizational factors elaborate, by events, the condition for the transfer of social hazard towards the physical realization of the accident or incident.

It is crucial for the industry to focus on ways to improve their workers' risk perception. Accidents may cause from small material losses (in which production is needed to stop for a while) to disasters involving harms to human beings or even human losses, incurring fines to the company. Adopting adequate safety culture always represent economic advantages for companies regardless the period of time for analysis, because an accident may occur at any time, not only in mid and long-terms.

The work done by the authors and reported in this paper implemented a manner to calculate and diagnose human reliability levels in workstations. By using principles from the C4t (Communication, Commitment, Competence and Cooperation) tool and some industrial safety policies widespread, it was intended to know whether divergencies would be found on operational mass' opinions about actions considered scientifically in favor of safety. Besides, if they could put them into practice when necessary, otherwise, get to know what prevents them to do so. High dispersion on responses would mean trouble in team consensus, and then a high possibility of workers' arbitrary decision-making and their actions to have mutual interference, may leading to ineffectiveness, especially in emergency situations. Also crucial to diagnose on human reliability is to find whether there is training that simulates a large number of possible abnormal conditions at work (as hard failures on productive systems) to teach and simulate how everyone should act in order to the practical procedures to be the same as those taught with great efficiency and effectiveness.

1.1 Risk and Accident Perception

1.1.1 Risk and Accident Perception overview

Risk and accident perception is a fundamental aspect of any person's life, for safety in the workplace, at home, in leisure time, etc. It is defined as the ability to detect real signs of danger or even to predict the occurrence of a negative situation. The perception is often influenced by context, individual's subjectivity, experience, trust, the way a problem is communicated and then analyzed (the Framing Effect), and even by heuristics, that are defined as cognitive processes used in decision-making required to be faster, in which part of not so relevant information is ignored. Kahneman and Tversky (1974) found that people overestimate results (considering the triggers as high-risk) from more recent and extraordinary events, for example, murders instead of thefts.

In some cases, one may refuse to face a certain risk situation because of fear, need for protection or believing that the possible benefits do not make it worth risking, and then, there is no need to do it. The concept associated with this early evaluation is Risk Tolerance, that is, the degree of risk severity that a person agrees to undergo. The relationships established by people in a group also influence their risk perception and risk tolerance. At work, for example, influencing factors divide into three groups and are related to the following theories [1].

Table 1 - Factors that Influence Human Risk and Accident Perception

LEVEL	FACTOR	ASSOCIATED THEORY(IES)	DESCRIPTION	ASSOCIATED RESEARCHERS
Macro-level Factors (institutional and structural)	1. Organization's Safety Culture	Social Action Theory	Society's perception that a certain activity is low risk.	Harding & Eiser (1984); Cooper (2003); Mullen (2004).
		Social Control Theory	Connect to the organization's policies to decrease unnecessary high-risk attitudes.	Hirschi (1969); Neal et al. (2000); Garcia et al. (2004); McNeely & Falci (2004); Clarke & Ward (2006); Ford & Tetrick (2011); Chapman et al. (2013).
	2. Enforcement and Organizational Trust.	Social Control Theory	The same as in item 1 of this table.	The same as in item 1 of this table.
Meso-level Factors (in general, by civil society groups)	3. Peer and Society pressure	Social Action Theory	The same as in item 1 of this table.	The same as in item 1 of this table.
		Situated Rationality Theory	Do not consider any high-risk attitude as irrational and safe attitudes as rational without previous analysis.	Rhodes (1997); Finucane et al. (2000); Mullen (2004); Vernero & Montanari (2007); Choudry and Fang (2008); Cafri et al. (2008); Keating & Halpern-Felsher (2008); Hambach et al. (2011).
	4. Inadequate leadership and Informal groups	Social Action Theory	The same as in item 1 of this table.	The same as in item 1 of this table.
Micro-level Factors (individual's psychological level)	5. Level of knowledge about the risk	Protection Motivation Theory (PMT)	People protect themselves when they predict that negative events may happen.	Becker & Maiman (1975); DeJoy (1996); Mearns et al. (1998); Gucer et al. (2003); Sheeran et al. (2013); Glendon & Walker (2013).
	6. Optimism bias + overconfidence	Risk Compensation Theory	Engaging in higher-risk situations by the feel of being safer because of safety equipment.	Wilde (1994); Aschenbrenner & Biehl (1994); Janssen (1994); Klen, (1997); Bridger & Freidberg (1999); Morrongiello et al. (2007).
		Habituated Action Theory	Risk perception decreases over time when no negative events occurred from high-risk attitudes.	Kasperson et al. (1988); Weyman & Kelly (1999); Weller et al. (2013).

1.1.2 Perception of traffic risk

Since attention is one of the requirements for good risk perception, it is known that performing certain activities with insufficient and/or diverted attention may cause harm. We can cite road transportation, in which some studies on risk perception were made in Europe by ESRA (European Survey of Road users ' safety Attitudes) [2]. More than 17000 respondents from 17 European countries participated. By the results, it was concluded that the main risk factors for road accidents were: driving under the effect of alcohol and drugs and lack of attention, rather than fatigue (ESRA, 2016). The survey also showed a remarkable characteristic of people: the feeling that the risk imposed by another person is more serious than the one in which the individual decides to face himself/herself without external influence. It was concluded from the results that for all three age groups interviewed (18-34, 35-54, and above 55 years) the scores attributed to the feeling of safety (which could range from 0 to 10) had around 0.5-higher mean value for people who were car drivers instead of car passengers.

1.2 Industry operation requirements for workstation project and operations control

The chemical industry has specific characteristics of technology, complexity in the tasks and risk of accident indicated by Figure 1. The plant project needs to meet physical-technological, cognitive and human requirements for the development of the tasks [3], otherwise, a human error should probably occur. After meeting them, it is crucial to set the criteria of the workstation for the best operation in routine in order to get better control of the task.

Due to the dynamics of processes, people and organizations, human error may also happen by behavioral (subjective and social aspects) deviances by the feeling of uncertainty in some work situations. It is possible to find what is the "level of adherence" (aimed in this paper) to safe procedures when those conditions are faced. The prediction of this behavior requires the measurement and monitoring of cooperation, commitment, communication, competence and stress levels, discussed in the C4T tool [4]. The operational control depends on the processes of standardization, communication, and analysis of the task and its failures. It is important to analyze their network relations, in addition to the way they affect or are affected by low risk perception. These factors are the basis for systemic (sociotechnical) failure [5], and they indicate the level of system reliability by function or region of process.

The conclusions may indicate informal rules adopted by the operator. In this investigation, according to Ávila [6], it is useful to find: (a) The difficulty/ease in installing informal communicational and technological barriers; (b) The way in which the group is aligned with good practices and principles of risk and reliability; (c) The issues of organizational cooperation and commitment; (d) The analysis of safety leadership and safety culture; (e) Cognitive gaps, workstation criteria and human performance factors management.

1.3 Risk in operating routine

The research group on dynamic risk needs to measure the subjective factors in the operational routine to project future behavior and the quality of risk perception. It is essential to check the safety principles and a good sense of leadership. It is important to analyze the scenarios and priorities [7], in addition to indicating gaps in cognitive processing and weaknesses in the workstation. This investigation intends to discuss the most appropriate interventions to adjust the safety culture by improving the team's risk perception, the most important input in cognitive processing. The C4t tool indicates the opening or closing of doors that allow the transit of danger energy in the human performance factors [4]. It must be considered that certain environments can set inadequate behavior for safety, quality, energy and cost control.

1.4 New Dynamic Risk Decision Tools

It was redefined not only reliability (human being, operation, process and equipment), sociotechnical reliability and reliability mapping, but also: factors affecting human performance (management, organization and operational culture), man's behavioral elements, deviances, failures and cultural phenomena that establish a safety culture. Figure 1 tries to represent that complex analysis. Letters from A to G were positioned on Figure 1 and their whole explanation is on Table 2.

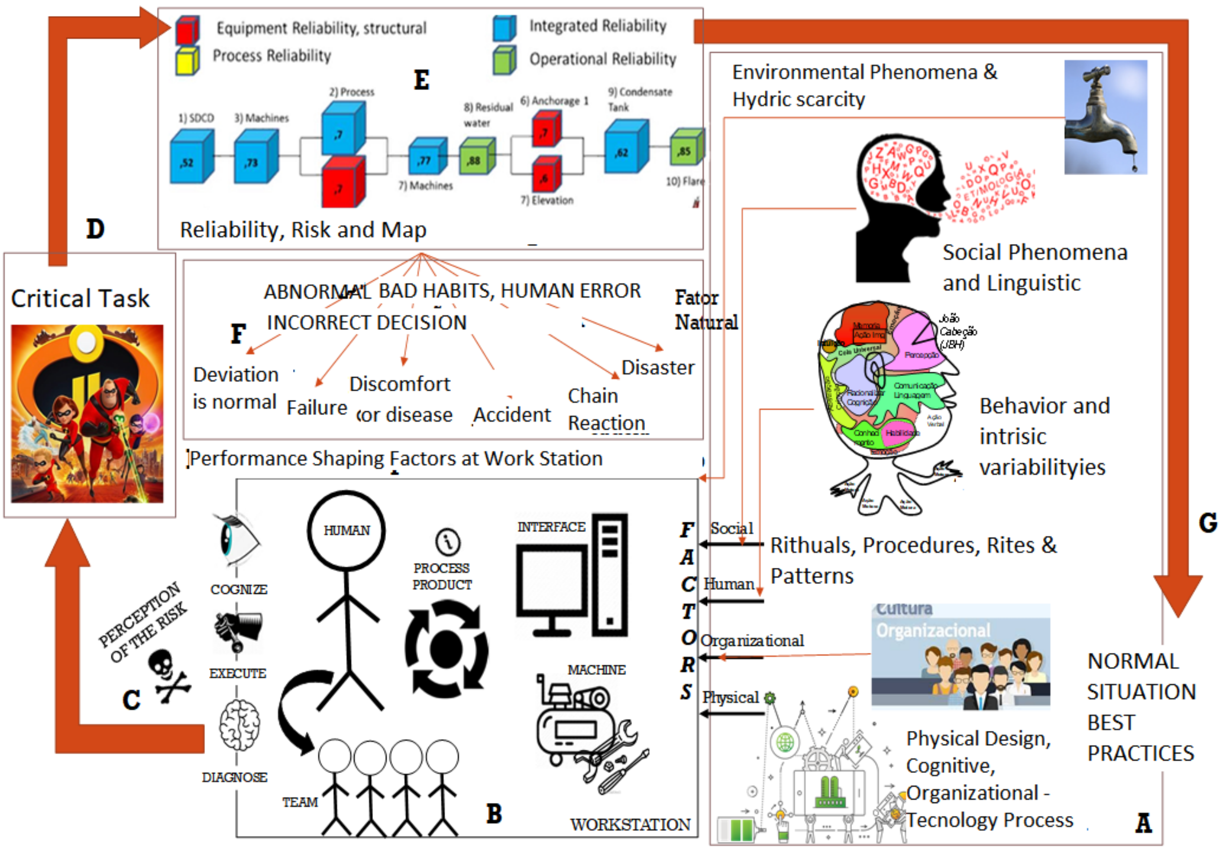


Figure 1 - Reliability and human factors in workstation design. Adapted from [6].

Table 2 – Auxiliary table to explain Figure 1

ITEM	DESCRIPTION
A	Requirements/guidelines for industrial and technological layout design should be found through analysis balancing: organizational principles; safety conditions; and workers' decision-making, performance, and limits.
B	Adequate interfaces should be provided to ensure clear and objective communication, avoiding conflicts between production-technology and workers' social phenomena. Interface examples: computer screens, written procedures, general feedback.
C	Risk perception must follow great safety guidelines to hinder the flow of danger energy and avoid interrupting the task/production due to human and material losses.
D	Safety-based procedures (how to act) must be taught and followed more seriously at critical tasks. A multidisciplinary view is needed to find root/main cause(s) and system limitations.
E	To calculate and diagnose human reliability, it is useful to construct a diagram including equipment, process, operation, etc.
F	All risks must be mapped. If deviances in safety procedures are accepted and the flow of danger energy is not controlled, it may happen failures, hazardous chain reactions, occupational diseases, and disasters.
G	Simple attitudes can bring great results in risk perception and preventing accidents in order to ensure good work conditions. Some of them are: changing leadership, giving feedback and improving man-machine interface. A multidisciplinary view is a must!

2 Methodology

A human risk perception improvement program led by the research group presented content about different elements of behavior and HOT factors to avoid the accident. A lecture lasting up to 8 hours was firstly presented in a chemical industry for the operational mass. It was like a training with the goal of sensitizing the operational mass. The concepts issued were divided into: Principles to spiritualizing safety; Investigating cognitive gaps in practices; Discussing the workstation criteria; and analyzing how to manage human factors.

The first block of content discusses the principles and concepts of risk, danger, reliability, behavior and human factors. By using examples of practical cases and routine situations, barriers to social, human and technological hazards are elaborated.

In the second block, cognitive models were presented to identify where and how failures of perception can occur in routine practices and/or accidents. Thus, the elaboration of a mind map for the decision and also physical and communicational actions was considered.

In the third block, discussions on workplace situations that can cause human errors are initiated. In addition, an analysis of the best criteria for the workstation is performed to identify the main constraints in the task and the main physical, cognitive and organizational factors. Related to these concepts, socio-human risk tools are presented, besides the importance of attention in industrial control.

The fourth block finished the training by a discussion on how to manage and intervene to change unsafe behavior. Among the tools reported, there were: the socio-human risk analysis; the C4T technique (measurement in human factors); the classification of cultural biases, bad habits, human errors and incorrect decisions; and the interventions on factors and human elements.

The preliminary diagnosis deals with the discussion of the principles and the respective hypotheses that should be validated in later work: cognitive gaps, risk perception, workstation criteria that cause errors, and management of indicators on human factors.

A transnational chemical industry, that adapts to local cultures, allows the existence of differences and seeks to improve safety standards. Handling behavioral aspects in consonance with technological aspects is a challenge, once considered the current characteristics of the hazardous energy environment and the complexity of the technologies. Probably because of this, the CCPS (Center for Chemical Process Safety) is concentrated in the discussion about what causes normalization of deviances and how to avoid the accident after organizational changes.

The different regions, leaderships, technologies, and organizations drive danger energy in the direction of the accident. The work of adjusting: the safety culture and the organizational culture, the interfaces involving the worker and the production, the quality of communication, cooperation levels and the level of commitment, require confirmation through routine (operator's discourse) or a poll during moments of sensitization.

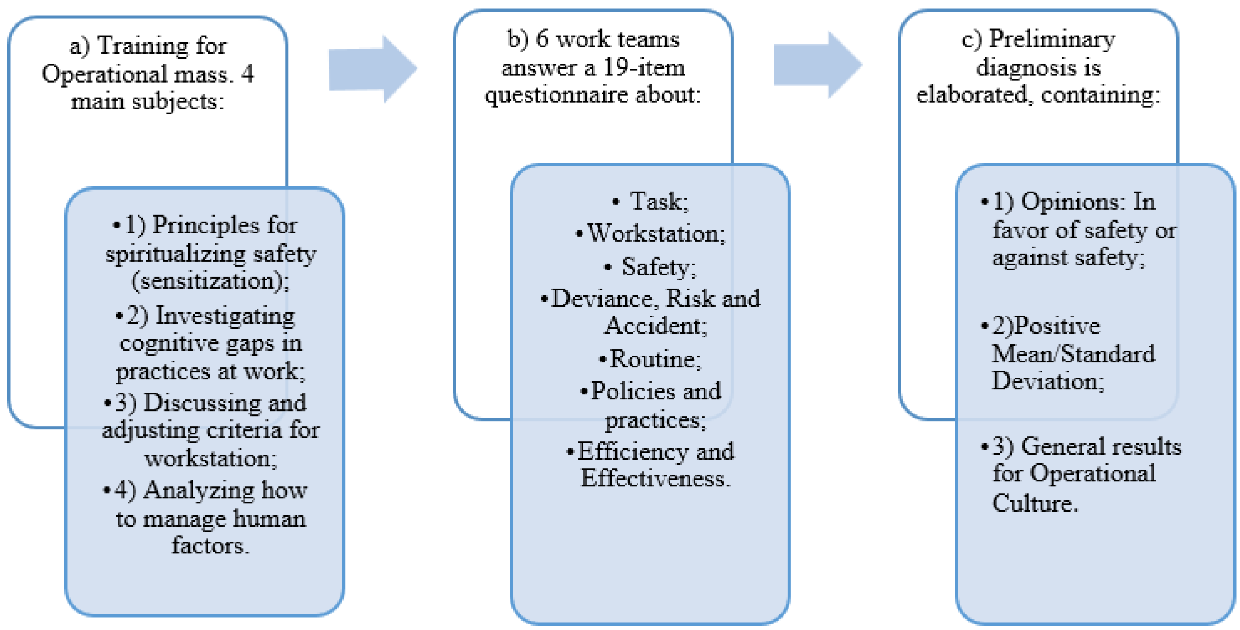


Figure 2 – Steps used for training, testing and diagnosing an industrial operational mass

3 Application

A diagnosis of general and specific aspects that affect the behavior of the work team was performed and interventions were needed to get out of the unsafe behavior. The diagnosis was based on the first stage of the 4-stage training.

The preliminary diagnosis in Figure 2 should be validated with additional safety data and multivariate data processing, and complementary discussion on cognition, workstation and Human factors.

The interventions depend on the validation of the hypotheses. They may be related to rituals, training, educational processes, operative groups, knowledge against failure, adjustments of HMI (Human Machine Interface), alarm system or other tools in Human Reliability Analysis (HRA) and Human Factors Analysis (HFA). It may be necessary to set an investigators team.

The training performed in the operational mass, divided into 6 groups (5 shift and one administrative work teams), during weekdays. The participation of the group must be active and adapted to limited time to provoke a break of paradigms in order to raise awareness. The "Insite" course for safety brings difficulties because of the intense operational routine. The questionnaires should not be revised, in order to avoid lack of representativeness in the statistical processing. An evaluation of the type of leadership and quality of attention should be done.

4 Discussion

4.1 Spiritualizing safety

Through 19 statements involving informal practices, principles and rules, it was intended to find relationships between behavioral aspects and intrinsic human performance factors or those resulted from managerial, organizational and operational relationships. The statements were related to keywords that indicate factors and elements (some showed in the most left-hand column in Table 3): communication, competence, avoiding production-safety conflict, leadership, procedures, good practices, human stress, political-practical conflict, communication and feedback, task and excessive self-confidence. Operating mass answers were treated statistically, making them possible to indicate getting closer or getting away in relation to the best practices in operational safety. The indicators can describe behaviors that represent operational culture, shift team leadership, informal shift rules, and some specific cases. These indicators can also show how danger energy circulates through the HOT (human-organizational-technical) elements and factors that build the Human Factors Bayesian Network. Other important elements and factors that have been indirectly discussed were: risk perception, economic bias, work training, standardization and work memory, information flow, selection and development, risk aversion, regional and global culture, opportunism, deviance normalization, centralizing management, social conflicts (generation, gender, multiculturism), control devices, alarm management, PLC (Programmable Logic Controller) or interface, instruments and PSV (Pressure Safe Valve).

Table 3 – 6 of the 19 questionnaire items evaluated by the authors, industry managers and supervisors as in favor (F) of safety, in blue "1"; or against (A) safety, in red "-1"

SUBJECTS	3) F	3) A	8) F	8) A	11) F	11) A	13) F	13) A	17) F	17) A	18) F	18)A	SUM: 1) to 19)
Communication											**1**		**2**
Competence							**1**						**2**
Avoid Production-safety conflict	**1**												**2**
Leadership										**-1**			**-1**
Procedures				**-1**									**-1**
Good practices			**1**										**1**
Human Stress									**1**			**-1**	**-1**
Political-practical conflict						**-1**							**-2**
Communication and Feedback					**1**								**1**
Task								**-1**					**-1**
Excessive Self-confidence								**-1**					**-1**

4.2 Group of issues in subject classes

The 19 sentences, here sometimes called ‘questions’ (because it was questioned about operational mass’ opinions afterwards), could be grouped into blocks of similar subjects: communication (questions 1; 11; 18), in which the answers showed a tendency to decrease the safety levels, demonstrating that the feedback is not enough and there may be a conflict between company policies and practice during routine and emergency. Competence (2, 13 and 15) had a high level of safety, indicating employees’ good competence, but the drop at question 15 showed a certain level of excessive self-confidence. Results from the conflict of priority between production and safety (items 3 and 6) demonstrated a tendency to normalization of deviance. Guilt culture and feedback in the procedure (7 and 8) results showed that culture is a strong factor in the company, which hinders the execution of good practices There was a low percentage that had perception about the need to "pay attention " in the context. Other results from the study appear after colon punctuations. Stress management by leadership (items 10 and 17): high positive percentage, a good perception for the influence of human factors by everyone, although dispersion on the answers resulted also high. Cooperation and Leadership (4, 12 and 14): despite demonstrating a leadership profile with active listening, the low percentage in favor of safety in questions 12 and 14 may indicate conflicts in leadership relations or between the staff and the shift teams, and a lack of adequacy at the workstation, task, and team. Commitment and fair culture (5, 9, 16 and 19): there was a fair culture, with employees committed to safety, and it is needed that the use of PPE (Personal Protective Equipment) by people becomes a habit in everyday life.

4.3 Question, sense and statistics for safety response

Before showing and commenting on the data collected from the questionnaire applied to a Brazilian chemical industry company, it is necessary to say that they represent correctly what is seen in most of chemical and other industries, although the data are not exactly the same because of their right of confidentiality**.** For this same reason, the region where it is located and also the technology used in their processes cannot be unveiled.

The 19 questions were grouped according to the 4.2 topic and the operational mass’ answers for some of them were described in Table 4, where blue means the percentage of opinions in favor of safety; those in red, against safety.

Some of the 19 sentences had their meaning been inverted before the questionnaire was given to the workers. These sentences are signaled by an asterisk in the end (Table 4). The inversion was due for not asking their opinions always the same way. That is, if a person sees many sentences scientifically in favor of safety, his/her first positive opinions about them tends to influence the other questions answers by the reason of being already accustomed to response positively. Once a sentence was inverted, by for example, putting the word ‘NOT’ in the middle (as on item 13 in Table 4), when a worker considered it against safety, the answer was registered at that table as in favor of safety, and vice-versa.

The key words indicating the subject are in the last column of the right. The positive (in blue) answers were statistically treated. Sentences evaluated by around and/or above 70% of respondents as favorable to safety, partially favorable and against safety were highlighted as following. In favor: competence, perception, emergency task, routine patterns, control stress; Partially favorable: workstation and operator’s function; Against: operational culture and guilt culture.

Table 4 – Averages of 6 operational mass groups' opinions for statements (items) as in favor, partially in favor or against safety

ITEM	STATEMENT	MEANING INVERTION?	Favor safety (F)	Partially favor (P)	Against safety (A)	ITEM KEYWORDS
11	Policies and practices are compatible in operation. There is no feedback without them.	No	**45%**	**23%**	**32%**	**Conflict between policies and practices; communication and feedback.**
18	Communication and action must be repeated as risk level increases.	No	**48%**	**24%**	**28%**	**Perception of risk; communication and stress (routine and emergency).**
13	The knowledge necessary to perform the activity does not include aspects of task identification and attitude-action in urgent situations. *	Answers A were considered F and vice-versa, due to the inversion of original statement meaning.	**92%**	**5%**	**3%**	**Routine; emergency (stress), competence and task.**
3	Competition between service measurement and quality hinders cooperative and safe work.	No	**48%**	**23%**	**29%**	**Conflict between production and security; Cooperation.**
8	Revise the patterns in time for correct routine management.	No	**93%**	**7%**	**0%**	**Procedure and standards; good practice.**
17	The operator should work under high stress level because his perception and safe acting remain the same. *	Answers A were considered F and vice-versa, due to the inversion of original statement meaning.	**70%**	**23%**	**7%**	**Stress (routine and emergency) and leadership.**

4.4 General behavior and comparison by teams in classes (Shift or staff)

The chart above, with the average of the 6 groups' opinions, was compared with the chart per training class for each one of the 19 questions. The discussion is about specific or general behaviors detected when the results from different teams are compared, in each question, to the mean values showed in Table 4. Some conclusions were as follows.

Questions 11 and 18 obtained from 18 to 45% of conviction of all classes interviewed that they had unsafe behavior. This fact indicated that problems use to occur between policies and practices not compatible with routine, besides low feedback. In addition, communication and action are not redundant as the risk increases.

Question 18 approaches communication and action. With the proposal that redundancy in communication and action raises attention to prevent deviance, it was obtained in all groups from 5 to 35% of the opinions as being against safety. In the average for all groups, the result was 28%.

Question 3, which stated that the "competition between measurements adopted in services and their quality hinders cooperative and safe work". The opinions obtained in each class range from 15% to 58% against security (29% for the mean value from all the classes).

The statement in item 13 was clearly linked to safe behavior. In all classes, 87% or 100% agreed that adequate knowledge to develop the activity includes attitude and action in the urgency task, and this would make the work safer.

Questions 13, 2, 18 are about issues in communication and competence. Although there were more answers in favor of safety, there were also other responses. Those questions were about policies and practices, observing deviances and communicating, etc.

The comparison involving results from an average for the 6 groups (those in Table 4) and 2 specifics of them, is shown in Figure 3. The 6 items detailed were, in sequence, 17, 8, 3, 13, 18 and 11, the most critical on conclusions and future work.

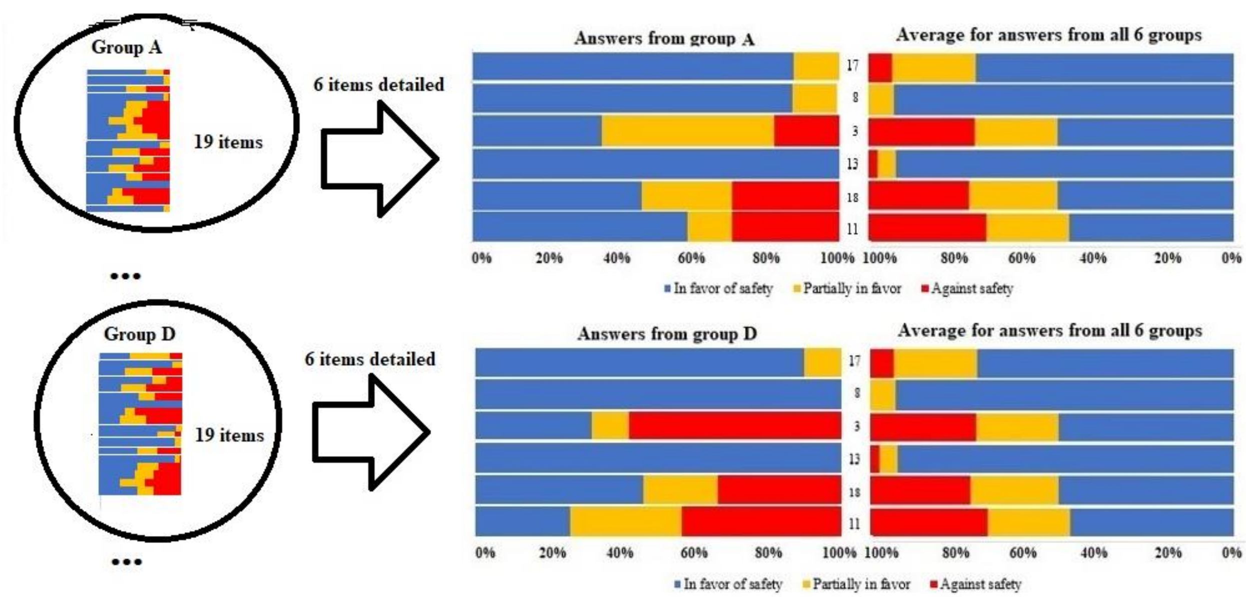


Figure 3 – Comparison between some groups' opinions and the average for 6 of 19 items evaluated by operational mass as in favor, partially or against safety.

4.5 Positive responses and Standard Deviation: an analysis by group and by question

In this analysis, it is important to establish the following criteria. An average of high results in favor of safety (close to 100%) with a low dispersion, that is, less variability in questionnaire answers indicates higher values for the ratio between positive mean and dispersion (positive mean/standard deviation), which indicates high safety. The smallest results for that ratio indicate the worst safety (these answers show the non-effectiveness of leadership in the safety culture).
Thus, the best results were for Q1 (To ask in doubt), Q4 (active listening vs pressure for results), Q13 (sufficient knowledge for emergency tasks) and Q19 (commitment). The items with worst scores follow: Q11 (compatible policies and practices), Q18 (redundancy in communication and signs of deviance), Q12 (operator's social and family roles versus operator's function), Q14 (positioning in workstation due to supervision). Table 5 shows some notes about specific results. Group E was divided into Group E(1) and Group E(2) parts because it was originally the biggest among all teams.

Table 5 – Some comments on the results for average and Standard Deviation

Worst results	Medium results	Best results
Question 11: All classes.	Questions 9 for Group E(2).	Q1 (ask in doubt)
Question 18 (except class E, part 2).	Questions 8; and 17 (procedures; and stress) scored mid result for group A.	Q13 (sufficient knowledge for emergency tasks.
In question 2: class E (part 1) and class D had low values.		Q4 and 19 (leadership, commitment)

Considering all the questionnaire, the following risk map could be constructed:

Table 6 – Risk map for the results from average/SD

Mean value for safety	0 – 25				Q11, Q12, Q14
	25.1 – 50	Q5, Q9, Q16	Q2		
	50.1 – 75			Q4, Q8, Q10, Q17	
	75.1 – 100	Q1, Q4, Q13, Q19			
		0 – 25	25.1 – 50	50.1 – 75	75.1 – 100
	Standard Deviation from safety value.				

It may also be interesting to see the values for positive mean/SD for each of the 6 teams in each question. Figure 4 shows:

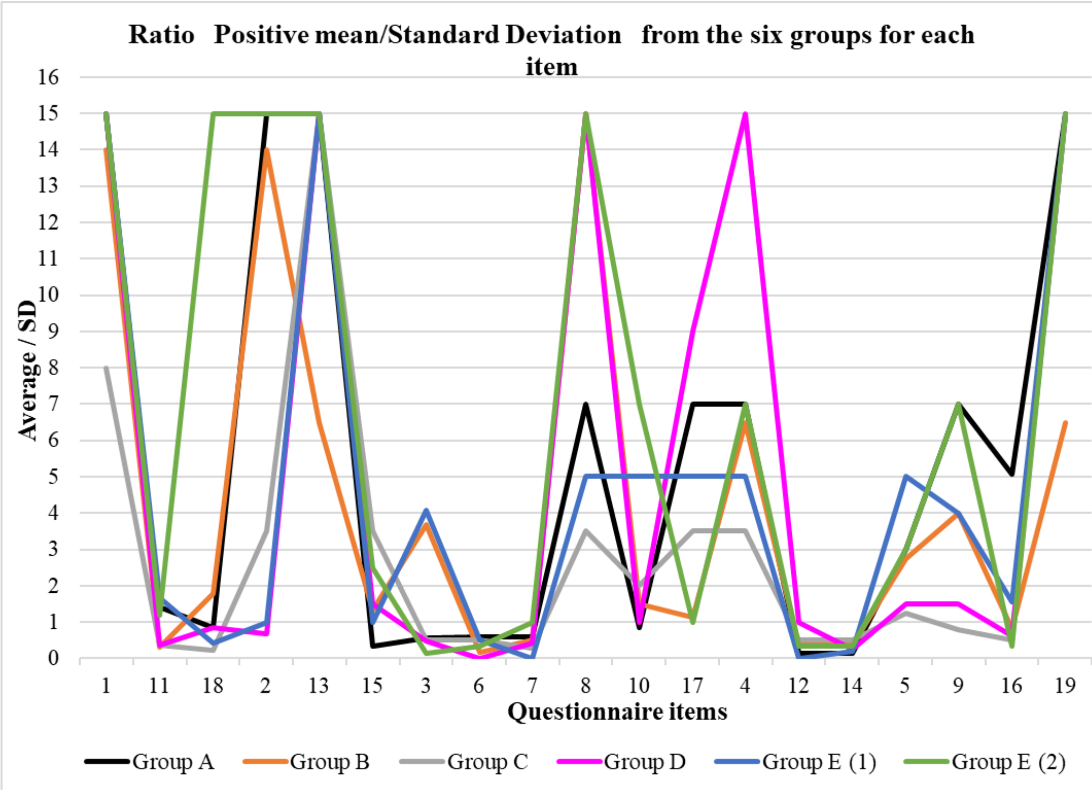


Figure 4 – Ratio Positive Mean/SD per group and per item plot

4.6 General results for Operational Culture

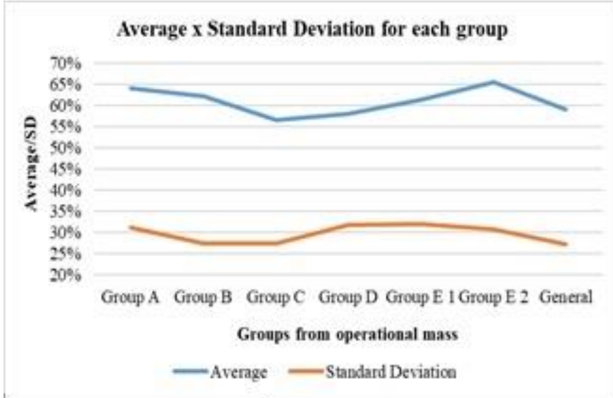
Figure 5 shows that for all the 19 items evaluated, each group had from 56% to 61% of positive opinions (they perceived them as in favor of safety). For a well-established safety culture, it is expected values above 75%. In terms of uniformity in response, around 27 to 32% in the standard deviation (SD). Thus, considering the groups mean value for F (favorable responses) and SD, the ratio F/SD = 58.5/29.5 = 1.98. Best results would range from 2.5 to 3.

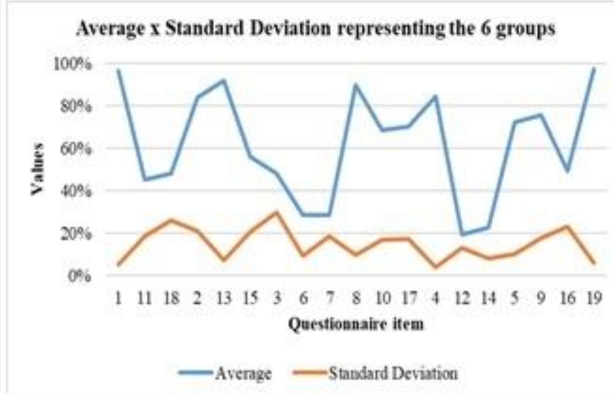
Team C had the worst performance in favor of safety and the teams A and E2 had very good results.

In Figure 5, by the plot for positive mean and SD for each question, it is noted that the highest score in favor of safety and the lowest standard deviation is the best result. Thus, in terms of positive responses, the highest were: Q1 (communication), Q13 (competence), Q19 (Commitment), Q8 (procedure), Q4 (cooperation), Q5 (commitment) and Q9 (fair culture) are the best results. The worst results: Q6 (conflict between production and security), Q7 (Procedures), Q12 (lack of cooperation), Q14 (cooperation and leadership).

In terms of standard deviation, smaller results indicate higher certainty, then: Q1, Q13, Q4, Q19. Higher results for SD indicate much dispersion in the group when commenting on the statements, thus, Q18, Q3, Q16. The dispersion results for other questions were normal, around 10%.

By dividing the positive responses by standard deviation, we have the following result: Q1, Q13, Q4, Q19 with very high values in favor of safety (above 10.0). The following questions scored badly, under 5.0: Q11 (communication), Q18 (communication), Q2 (competence), Q15 (competence), Q3 (priority production versus security), Q6 (priority production versus security), Q7 (procedure), Q12 (cooperation), Q14 (cooperation).





Aggregation parameter	Questions			
Communication	1	18	11	
Competence	2	13	15	
Conflict between production and safety	3	6		
Guilt culture /procedures	7	8		
Leadership/Stress	17	10		
Leadership relationship and Profile	4	12		
Commitment/Fair culture	5	9	16	19

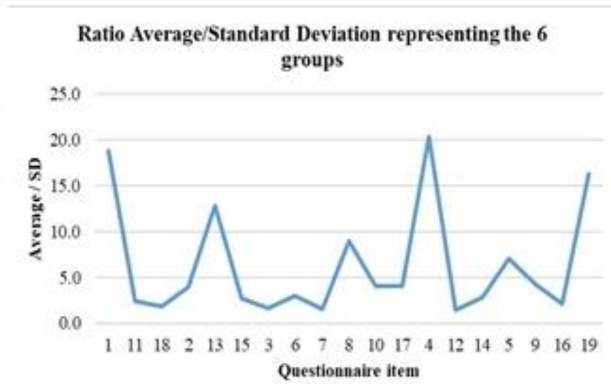


Figure 5 – General results for Operational Culture per item and per group. The word 'Average' at the plots titles means the same as 'Positive Mean', said before

4.7 New Concept: Intrinsic Relationship, Work Network, Graphs and Perception

Inadequate safety conditions that can cause incidents may incur problems of higher severity, that is, accidents. The chemical industry, in general, has decreased the number of incidents throughout the last years, but there is almost no reduction of accidents with or without lost days. There is, apparently, no connection between the various risks that might trigger situations of danger in routine, which makes no sense. It is noted, therefore, that results like above are caused by cases of no notification for serious problems, because of guilt culture, no priority in safety, and others. There is a gap between the safety asked by organizations, as in policies adopted, and the safety seen in practice.

The behavior present in many industries nowadays can be called as 'reactive', that is, it only starts to react in terms of safety and organizational culture after an accident occurs. The goal to be achieved by any organization that seeks to work well by balancing production, safety and human factors, is a proactive behavior with good leadership(s). Protective actions to avoid accidents all the time, especially when it is seen any deviation of conduct or even signs indicating a possibility of danger in the future, commonly known as predictive behavior. It is useful the following to activate that behavioral model: enhancing the safety culture, improving the availability and quality of trainings, make security and operation work together, promoting better active listening and clear communication, acknowledge good practices, managing risks, changes and incidents, and effectively integrating actions in different organizational areas to improve risk perception.

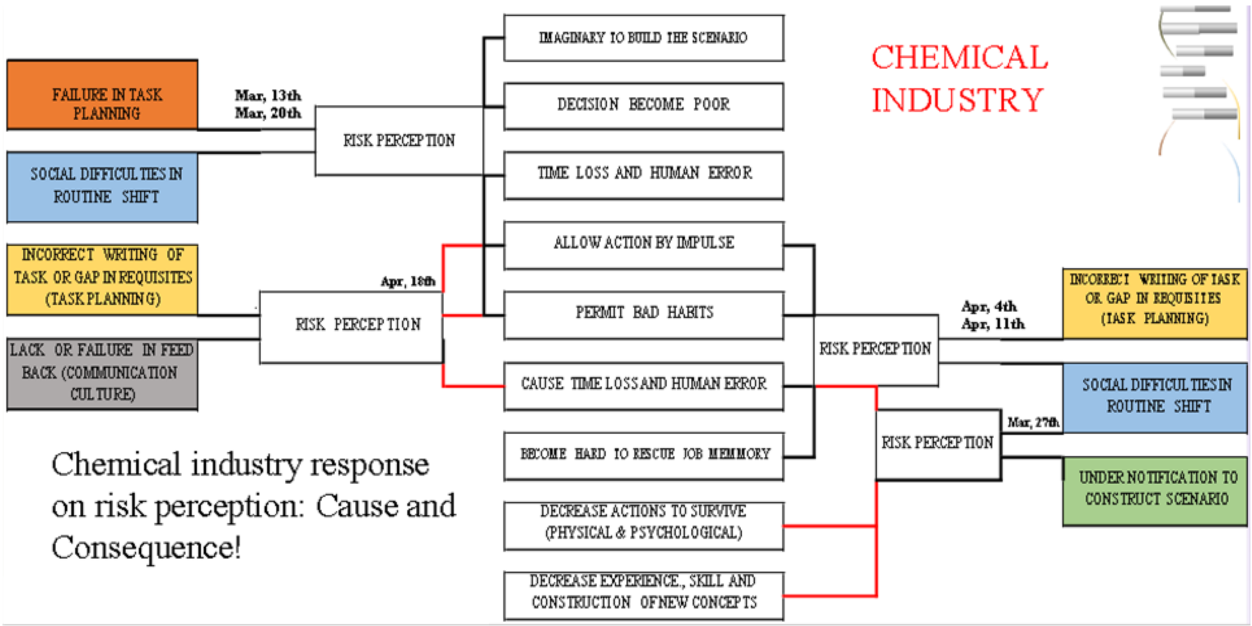


Figure 6 - Reliability and human factors in workstation design

5 Conclusions & Future Work

Some important points collected from the results of the diagnosis were: (1) Change the idea of the best work team for the one that reviews and respects the safety-based procedure; (2) Do not inspire fear for delay or possibility of failure; (3) Get to know how to discuss conflicts and priorities through good practices and giving feedback; (4) To understand that communication must be redundant because there might be some incorrect information; (5) Observe the real scenario before critical actions; (6) Take care when accelerating services and seek to set a climate of cooperation. Besides, it is important to intensify strong points bonds as: (7) emergency knowledge; (8) in doubt, always ask; (9) communicate any deviations; (10) Keep the stress controlled; (11) Active listening; (12) The patterns for the routine; and (13) avoid losses.

Risk and Human factors are often subjective, which hinders the application of appropriate techniques that can see the present moment and then design the future. Resilient organizations need to develop tools to confirm the risk perception in industrial critical tasks. Many companies with stable safety programs have encountered behavioral changes and unexpected accidents, confirming the lack of perception of changes over time in teams and leadership. Thus, low risk perception should be diagnosed from different perspectives that include: culture (principles), operation (cognition and practices), design (criteria for the workstation) and management (identification and measurement of human factors quality). This work was done in a real case of the chemical industry and complex process from questions elaborated after research on human factors. It intends, in the future, to help build the Bayesian Network indicating the regions, functions, appropriate subjects for corrective and preventive actions.

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